

Progress in Designing the DPSSL for LLNL's Project Mercury ¹

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Project Mercury is a three-year project at the Lawrence Livermore National Laboratory (LLNL) to design (FY97), build (FY98), and operate (FY99) a 100-joule 10-Hz diode-pumped solid-state laser (DPSSL) that is compatible with scaling to >1 kJ in future single-arm systems, and eventually to inertial fusion energy (IFE) systems at the MJ scale.² The goals include an overall electrical efficiency of 10% or more, a final focus less than 5 times the size of a diffraction-limited beam, and pulse lengths of 1 to 10 ns. The gain medium selected is Yb:S-FAP [i.e., Yb³⁺-doped Sr₅(PO₄)₃F] pumped at about 900 nm, operated at 1047 nm for 1 ω , and harmonically converted to 2 ω with a conversion efficiency exceeding 50%.

In this paper, we present the progress made in designing the laser. This work includes 3D Monte Carlo ray-trace modeling of the light as it leaves the diodes and passes through a lens duct and a light homogenizer on its way to the gas-cooled gain-medium crystals, with considerations for bandwidth and polarization. The diode light pumps the gain medium via a code that includes the anisotropic nature of the Yb:S-FAP emission cross sections, as well as the wavelength dependence of the laser line shape and the anisotropic polarization-dependent amplified spontaneous emission (ASE). The laser architecture includes a fiber oscillator, regenerative preamp, and 4-pass DPSSL amplifier. This architecture is being optimized in 1D and 2D with the OPTIMA1 optimization code using the 3D modeling and the PROP92 propagation code, which provides direct analysis of the final beam quality.

Project Mercury is intended to provide a natural extension of the solid-state-laser technology of the National Ignition Facility (NIF) towards IFE applications.

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² C. D. Orth, S. A. Payne, and W. F. Krupke, "A Diode-Pumped Solid-State Laser Driver For Inertial Fusion Energy," *Nuclear Fusion*, Vol. 36, No. 1 (1996), pp. 75–116.